



INVESTOR IN PEOPLE

CERTIFIED COPY OF PRIORITY DOCUMENT

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

11000 U.S. PTO
109/898485
07/05/01



I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 22 June 2001

This Page Blank (uspto)

THE PATENT OFFICE
D
10 OCT 2000
NEWPORT

The
**Patent
Office**

10 OCT 2000 E574672-1 D00393
P01/7700 0.00-0024735.3

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

2000P04896/GB/R76/MM/rr

2. Patent application number

(The Patent Office will fill in this part)

0024735.3

10 OCT 2000

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

ROKE MANOR RESEARCH LIMITED

OLD SALISBURY LANE
ROMSEY, HAMPSHIRE, SO51 0ZN
UNITED KINGDOM

Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

UNITED KINGDOM

5615455007

4. Title of the invention

IMPROVEMENTS IN OR RELATING TO BUFFER MANAGEMENT

5. Name of your agent (*if you have one*)

DEREK ALLEN

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

Siemens Shared Services Limited
Intellectual Property Department
Siemens House, Oldbury
Bracknell, Berkshire RG12 8FZ
United Kingdom

Patents ADP number (*if you know it*)

7396419002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (*if you know it*) the or each application number

| Country | Priority application number (<i>if you know it</i>) | Date of filing (day / month / year) |
|---------|--|--|
| GB | 0016474.9 | 05/07/2000 |

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an applicant, or
 - c) any named applicant is a corporate body.
- See note (d))

- Enter the number of sheets for any of the following items you are filing with this form.
Do not count copies of the same document

Continuation sheets of this form 0

Description 7

Claim(s) 1

Abstract 1

Drawing(s) 3

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 2 /

Request for preliminary examination and search (Patents Form 9/77) 1 /

Request for substantive examination (Patents Form 10/77)

Any other documents
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

Date 06.10.2000

Margaret Mackett

12. Name and daytime telephone number of person to contact in the United Kingdom

Margaret Mackett

01344 396808

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- b) Write your answers in capital letters using black ink or you may type them.
- c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- e) Once you have filled in the form you must remember to sign and date it.
- f) For details of the fee and ways to pay please contact the Patent Office.

IMPROVEMENTS IN OR RELATING TO BUFFER MANAGEMENT

The present invention relates to improvement in or relating to buffer
5 management, and is more particularly concerned with reassembly buffer
management.

In the Internet, data is transferred over a global network of
heterogeneous computers by means of a plurality of routing devices in
accordance with a standard protocol known as Internet Protocol (IP). IP is
10 a protocol based on the transfer of data in variable sized portions known as
packets. All network traffic involves the transportation of packets of data.

In Asynchronous Transfer Mode (ATM) networks, data is transferred
in small cells of a fixed length, typically carrying 48 bytes of data. ATM
allows high transmission rates by keeping the overheads due to
15 communication protocols to a minimum and by implementing the majority
of the communication protocols in hardware. In particular, ATM routing is
achieved entirely in hardware. In ATM, virtual circuits between senders
and destinations called virtual channels are established, the set-up and the
maintenance of the virtual channels being implemented in hardware to
20 minimise switching delays.

Routers are devices for accepting incoming packets; temporarily
storing each packet; and then forwarding the packets to another part of the
network. For the purposes of the following description the term 'routing
device' refers to any device which performs the function of a router or a
25 circuit switch. One relevant example of a routing device is an ATM to IP
switch.

There is an urgent requirement for routing devices that can route IP traffic at extremely large aggregate bandwidths in the order of several terabits per second. Such routing devices are termed "terabit routers".

When an IP packet is transmitted between routers over an ATM link,
5 the packet must be segmented into fixed length ATM cells. The receiving router must reassemble the original packet from the cells as they arrive.

Conventional reassembly proceeds as follows:

First, a free pool of packet buffers (or reassembly buffers) is maintained. Secondly, on arrival of the first cell for a given packet,
10 a packet buffer is allocated from the free pool. Packet data is copied from the cell into the buffer and a timer is started. The timer is known as a reassembly timer whose function is to protect the system from lost cells.

Upon arrival of each subsequent cell for the given packet, except the last, packet data is copied from the cell into the buffer. After each new
15 copy event, the reassembly timer is restarted. On arrival of the last cell for the given packet, packet data is again copied from the cell into the buffer and the reassembly timer is stopped. The new complete packet is processed and transmitted to its intended destination or destinations. The buffer is then returned to the free pool.

20 If the reassembly timer expires, it is assumed that one or more cells have been lost or corrupted. In this case, the reassembly is abandoned and the buffer is returned to the free pool.

It is important to note, however, that the router must perform multiple concurrent reassemblies. Typically, the router will have a number
25 of ATM virtual circuits open, each carrying data from IP packets. Within any one virtual circuit, the cells for a given packet will arrive contiguously. However, the cells for the given packet arriving on different virtual circuits will be interspersed relative to one another, which also means that cells

from different packets will be interspersed. It is possible that concurrent reassemblies be required for each virtual circuit, each requiring its own timer. For high capacity routers with large numbers of virtual circuits, large numbers of timers are required.

5 It is therefore an object of the invention to obviate or at least mitigate the aforementioned problems.

In accordance with one aspect of the present invention, there is provided a method of operating a reassembly buffer function, the method comprising the steps of:-

- 10 a) receiving a first fragment from a new packet;
 - b) allocating a buffer location to the new packet;
 - c) moving the allocated buffer location to the end of a buffer list;
 - d) receiving subsequent fragments and passing them to the allocated buffer location and repeating step c);
 - 15 e) transmitting reassembled packet from the allocated buffer location when the last fragment has been received;
 - f) allowing the allocated buffer location to reach the top of the buffer list if no further fragments are received; and
 - g) reusing the allocated buffer location when it reaches the top of
- 20 the buffer list.

A fragment is defined as a part of a packet of data which is transmitted separately due to the constraints of a network. A fragment may be a cell or an IP fragment.

An advantage of the present invention is that it allows the reassembly
25 of variable length packets from fixed length cells in the absence of reassembly timers.

In one embodiment of the present invention, a method for reassembling variable length Internet Protocol (IP) packets from fixed

length Asynchronous Transfer Mode (ATM) cells in the absence of reassembly timers is provided.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 illustrates an ATM network;

Figure 2 illustrates a device for reassembling packets of data in accordance with the present invention; and

Figure 3 illustrates a buffer comprising a part of the Figure 2 device.

Figure 1 illustrates an ATM network 100 to which are connected a plurality of packet switches or routers 102, 104, 106, 108, 110, 112.

Although only six packet switches or routers are shown, it will be appreciated that any number of such switches or routers may be connected to the network 100 as required by a particular application.

Each packet switch 102, 104, 106, 108, 110, 112 is connected to each of the packet switches via the network 100. Although the network 100 is described as an ATM network, it may also be an internet protocol (IP) network.

Each packet switch 102, 104, 106, 108, 110, 112 can be considered to be an interface unit for a terabit router (not shown). Such a router, for example, RipCore (Registered Trade Mark), comprises a plurality of interface units, each interface unit having to support interface speeds of 2.5, 10 and 40 Gigabits per second. Therefore, packet handling has to be as simple as possible to allow the higher levels of hardware integration required and reduce development risk.

The present invention will now be described with reference to a terabit router, but it will readily understood that it is equally applicable to packet switches or any device where packet data reassembly needs to take

place. One particular instance where packet data reassembly is required is at the ingress to a packet switch or a terabit router.

Figure 2 illustrates a terabit router 200 which comprises an input 202 for receiving packets of data, in the form of cells, from a network (not

5 shown). The router 200 includes a cell receive function 204 for receiving individual cells from the network and forwarding the cells to a reassembly buffer 206 where the cells are collected and reassembled into their original packets of data. The reassembled cells are output from the router 200 on output 208. The buffer 206 is described in more detail with reference to

10 Figure 3.

In Figure 3, the buffer 300 comprises a plurality of buffer elements 302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336, 338, 340 arranged in a list. It will be appreciated that, although twenty buffer elements are shown, any suitable number can be

15 employed in accordance with a particular application.

As shown in Figure 3, element 302 is at the top of the list and is therefore free for use, element 340 contains at least one cell from a packet, and element 318 may contain a substantially reassembled packet. This is given by way of example. It will be appreciated that element 318 may also be free as it is in the middle of the list. Furthermore element 340 may also be free if the packet reassembly has only just begun.

In an embodiment of the present invention, the following steps are implemented on a terabit router:-

First, a packet buffer free pool, buffer 300, is maintained as a linked 25 list. The linked list is known as a 'free list'.

When the first cell for a given packet arrives, a buffer element is taken from the head of the free list, for example, buffer element 302, and the packet data from the first cell is copied into that buffer element. The

buffer element is then moved to the end of the free list, as shown by arrow 342. Buffer element 340 then moves off the end of the list in the direction indicated by arrow 344.

- On arrival of subsequent cells for the given packet, excluding the
- 5 last, the packet data is copied into the relevant buffer element and the buffer element is moved to the end of the free list.

- On arrival of the last cell for the given packet, the packet data from the last cell is copied to the buffer element and the complete packet is processed, and passed to output 208 as shown in Figure 2. Once the
- 10 reassembly has taken place, the buffer element moves up the list in the direction indicated by arrow 344 until it is at the top of the list and the process re-starts for a new packet.

- If cells for a packet are lost so that the complete packet is never received, the buffer element will eventually, as a result of buffer allocations
- 15 for other packets, reappear at the head of the free list, as indicated by arrow 344, and be re-used for a new packet. The failed reassembly is automatically abandoned.

- This is repeated for each individual packet of data so that only one buffer element collects cells relating to a particular packet of data, and
- 20 there is an effective time out when the buffer element reaches the top of the list.

It will be readily appreciated that this technique could also be used for protection against certain so-called "denial of service" attacks upon computer networks.

- 25 IP supports packet fragmentation to allow large packets to be transmitted over networks which contain links with physical limits on their packet sizes. Accordingly, a large packet may be broken into a number of small packets to be reassembled at their ultimate destination. This makes

the network vulnerable to attack. A hostile agent may send to its target a large number of single fragments each identified as belonging to larger packets, but for which no subsequent fragments are sent. The target (using a conventional reassembly scheme as described above) will reserve
5 resources for each reassembly, resulting in buffer exhaustion. It is difficult to combat this sort of attack through the use of reassembly timers since if the timers were to be short enough to be effective, they would not be long enough to accommodate the arrival of real fragmented packets.

A target using a reassembly scheme in accordance with the present
10 invention is much less likely to suffer buffer exhaustion under such denial of service attacks. Bogus fragments do waste bandwidth but have no ultimate effect on the free pool.

CLAIMS:

1. A method of operating a reassembly buffer function, the method comprising the steps of:-
 - a) receiving a first fragment from a new packet;
 - b) allocating a buffer location to the new packet;
 - c) moving the allocated buffer location to the end of a buffer list;
 - d) receiving subsequent fragments and passing them to the allocated buffer location and repeating step c);
 - e) transmitting reassembled packet from the allocated buffer location when the last fragment has been received;
 - f) allowing the allocated buffer location to reach the top of the buffer list if no further fragments are received; and
 - g) reusing the allocated buffer location when it reaches the top of the buffer list.
2. A method according to claim 1, further comprising the step of using the position of the allocated buffer location in the buffer list to effect timing for receipt of fragments from each packet.
3. A method of operating a reassembly buffer function substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT
IMPROVEMENTS IN OR RELATING TO BUFFER
MANAGEMENT

Described herein is a method for reassembling variable length packets from fixed length cells. When a variable length packet, for example, an Internet Protocol (IP) packet, is transmitted between routers over a link which transmits data as fixed length cells, for example, an asynchronous transfer mode (ATM) link, the packet must be segmented into compatible fixed length cells. The receiving router must reassemble the original packet from the cells as they arrive. A packet buffer free pool (300) is provided which is maintained as a linked list, known as a 'free list', and which comprises a plurality of buffer elements (302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336, 338, 340). When a first cell for a given packet arrives, a buffer element (302) is taken from the head of the free list and allocated to that packet. The packet data from the first and subsequent cells is copied into the allocated buffer element and each time the buffer element is moved to the end of the free list. Upon the arrival of the last cell for the given packet, the complete packet is processed. Failed reassemblies are automatically abandoned as the buffer element is reused when it reaches the head of the free list. This technique is relevant to protection against "denial of service" attacks upon computer networks.

(Fig. 3)

This Page Blank (uspto)

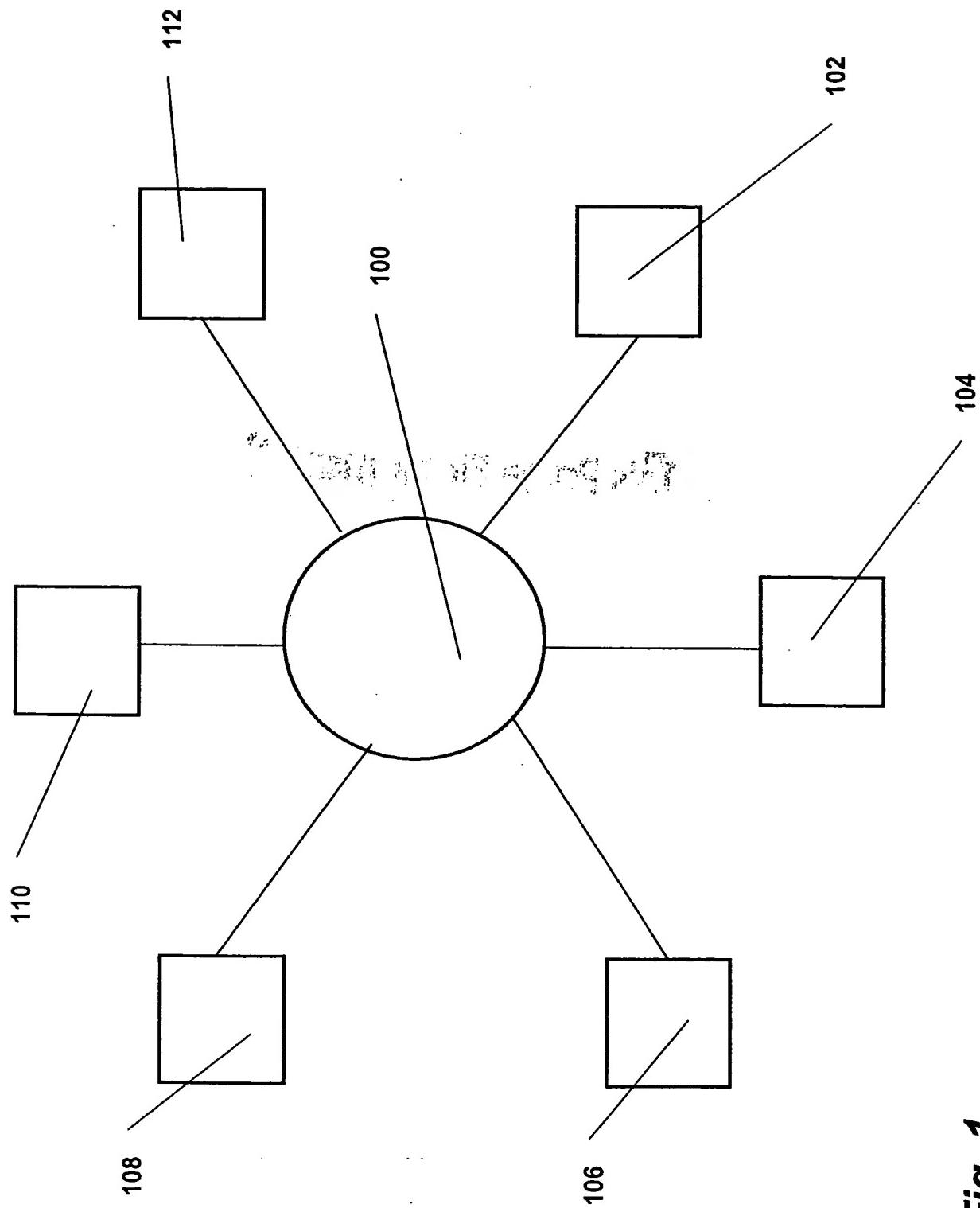


Fig. 1

This Page Blank (uspto)

2/3

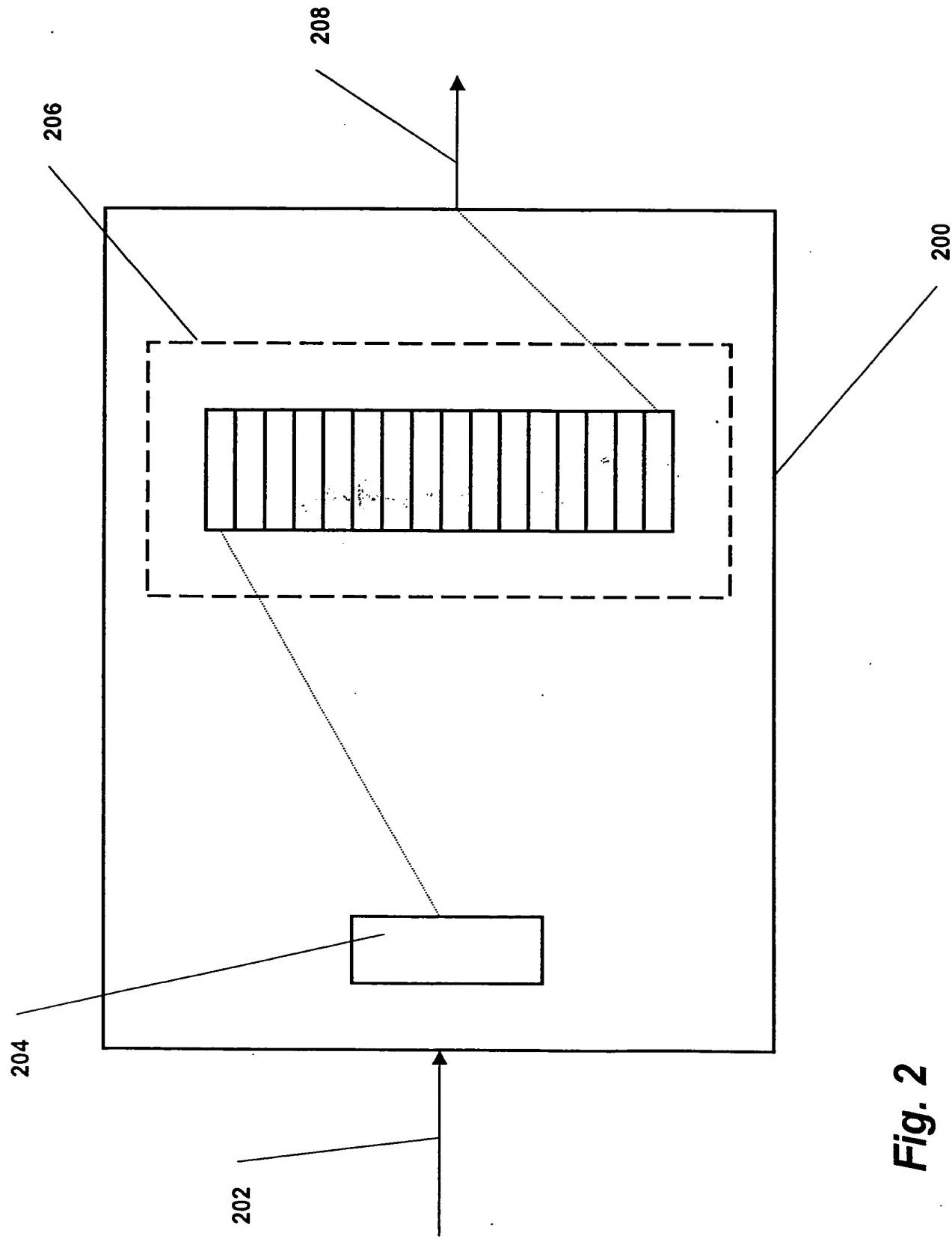


Fig. 2

This Page Blank (uspto)

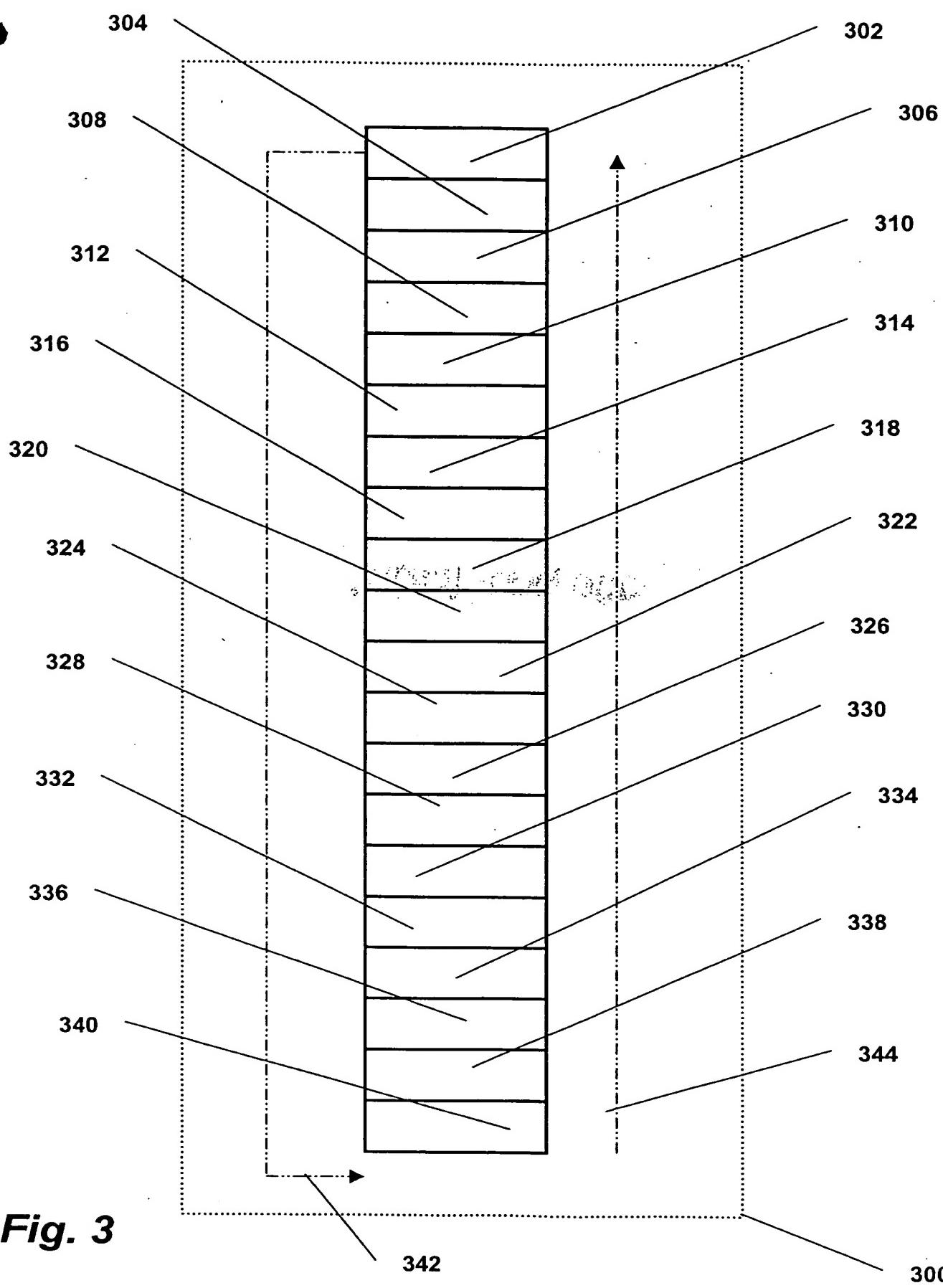


Fig. 3

This Page Blank (uspto)